Marshall

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D C 20546

REPLY TO ATTN OF: GP

OCT 15 1973

TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,751,733

Government or Corporate Employee : North American Rockwell Los Angeles Division, LA, CA.

Supplementary Corporate Source (if applicable) :

NASA Patent Case No. : MFS-16,570-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [X] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

United States Patent [19]

Fletcher et al.

[11] **3,751,733**

[45] **Aug. 14, 1973**

[54] **TACTILE SENSING MEANS FOR PROSTHETIC LIMBS**

[76] Inventors **James C. Fletcher**, Administrator of the National Aeronautics and Space Administration with respect to an invention of, **Walter L. Scott**, Anaheim, Calif.

[22] Filed **Feb. 22, 1972**

[21] Appl No **228,150**

[52] **U.S. Cl.** . 3/1.1, 3/2, 3/6, 3/12

[51] **Int. Cl.** A61f 1/00, A61f 1/06, A61f 1/08

[58] **Field of Search** . . .. 3/1-1 2, 3/12, 2, 6, 340/407, 214/1 CM

[56] **References Cited**

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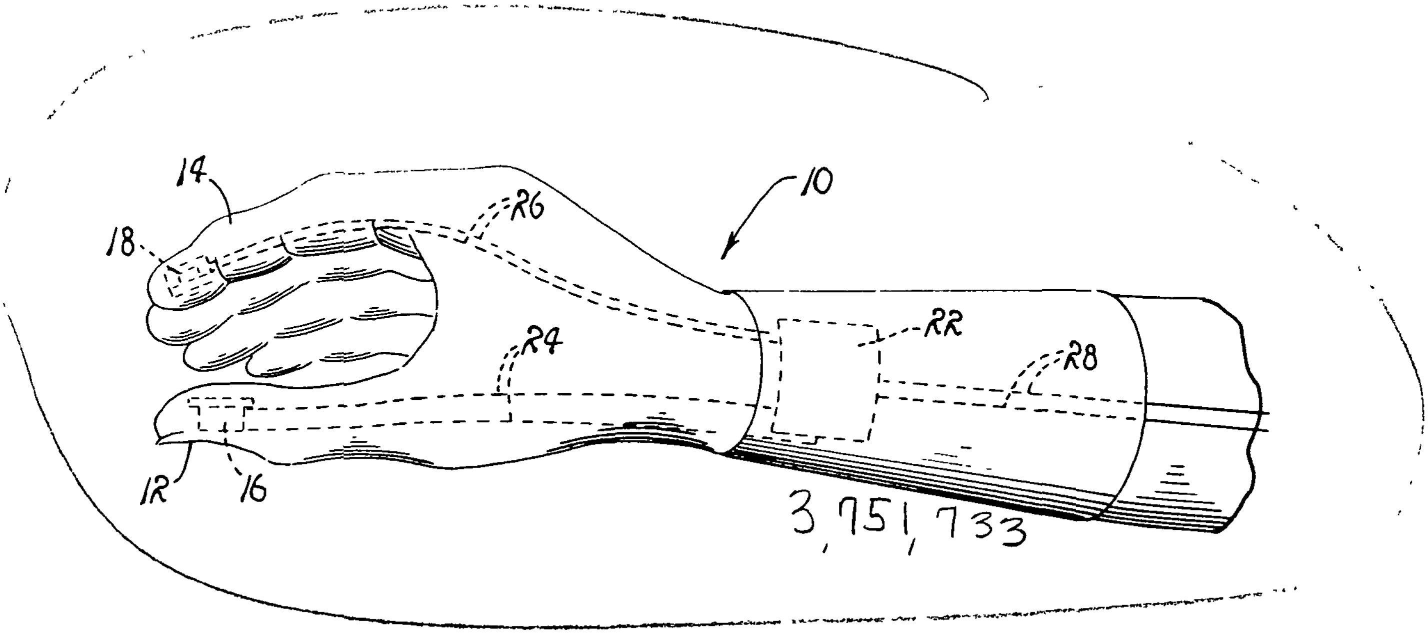
Primary Examiner—Richard A Gaudet
Assistant Examiner—Ronald L. Frinks
Attorney—L D Wofford, Jr and John R Manning

[57] **ABSTRACT**

An improved prosthetic device characterized by a frame including a socket for mounting the frame on the stump of a truncated human appendage and having a plurality of flexible digits extended from the distal end thereof. Within the digits there are transducers, provided as sensing device for detecting tactile stimuli, connected through a power circuit with a slave unit supported by a strap and fixed to the stump, whereby the tactile stimuli detected at the sensing devices are reproduced and applied to the skin of the appendage for thus stimulating sensory organs located therein

1 Claim, 4 Drawing Figures



PATENTED AUG 14 1973 3,751,733

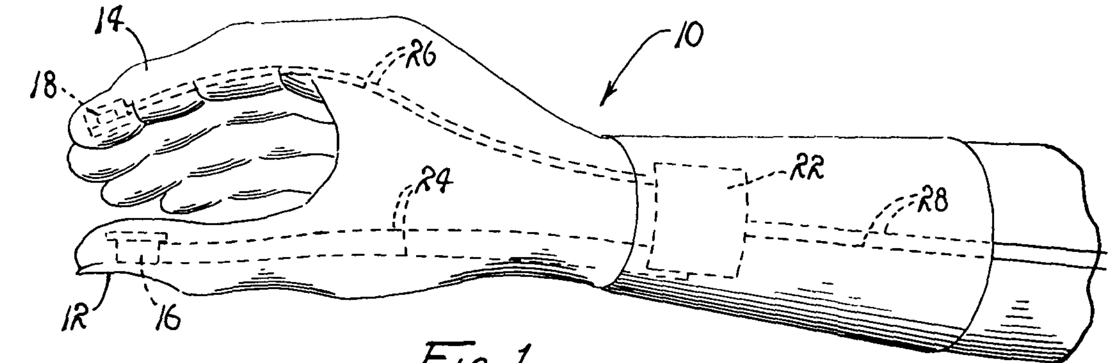


FIG. 1.

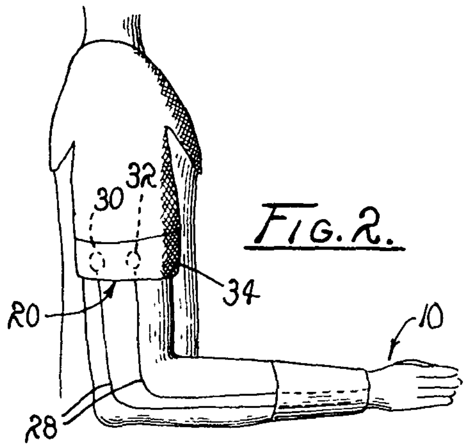


FIG. 2.

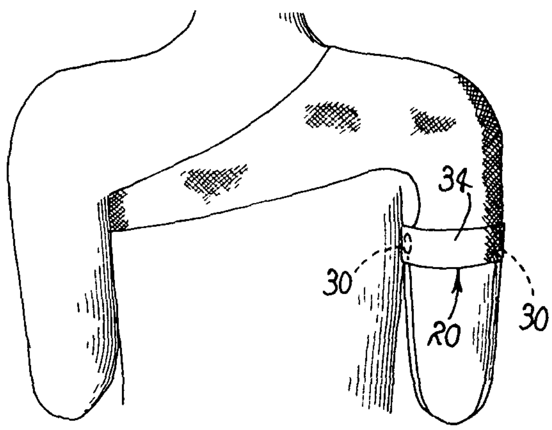


FIG. 3.

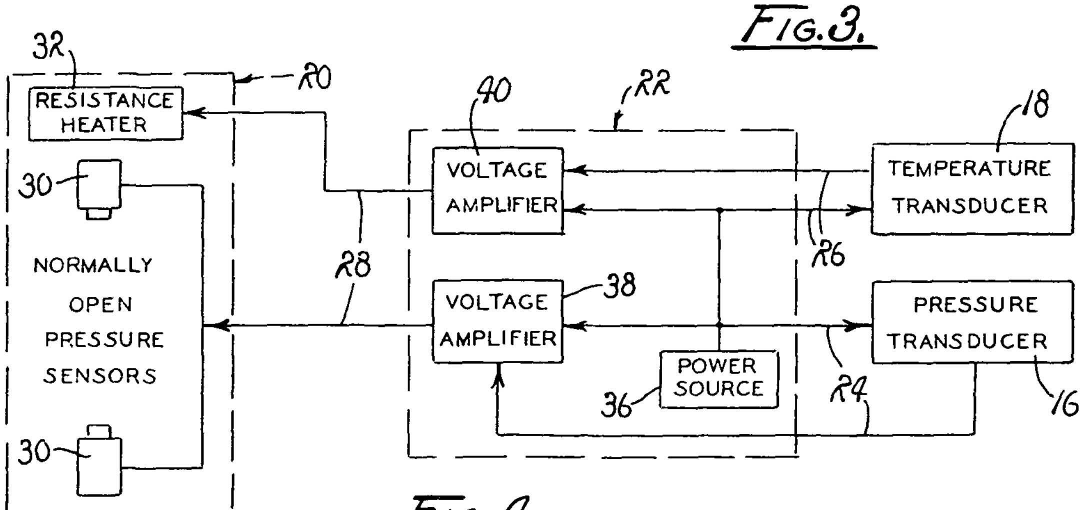


FIG. 4.

TACTILE SENSING MEANS FOR PROSTHETIC LIMBS

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat, 435, 42 U S.C 2457)

BACKGROUND OF THE INVENTION

The invention relates generally to prosthetics and more particularly to an improved prosthetic device having sensing means supported within the digits thereof for detecting tactile stimuli, and a slave unit driven in response to the detected stimuli for stimulating the sensory organs within the stump of a truncated appendage

The prior art is replete with teachings of electromechanical prosthetic devices having tactile sensors mounted therein and employed in controlling the operation of the device Such a device is shown and described in U S Pat No 3,509,583 to Anthony V Fraioli.

Tactile sensors are employed in such devices for purposes of controlling the operation thereof Normally, the sensors are transducers so connected with selected drive units within the device that the drive units respond to output signals derived from the sensors in order to avoid application of excessive pressures to objects supported within the device

Currently available prosthetic devices suffer a common deficiency in that the wearer of the device is insulated from tactile stimuli to which the device is in normal usage subjected Consequently, a wearer cannot detect stress and heat or the magnitude of the stress or heat applied to the device through touch or taction

Hence, there currently exists a need for an improved prosthetic device which affords the wearer an opportunity to "feel" pressure, heat and similar tactile stimuli to which the device is subjected through taction.

SUMMARY OF THE INVENTION

It is therefore an object of the instant invention to provide an improved prosthetic device

It is another object to provide an improved prosthetic device having sensing units supported by the digits and coupled with slave units responsive to the sensing units for stimulating the sensory organs within the stump of a truncated appendage.

It is another object to provide an improved prosthetic device through which tactile stimuli are applied to the wearer in response to an application of tactile stimuli to the device.

It is another object to provide in a prosthetic device a plurality of transducers for electrically detecting tactile stimuli and for applying to sensory organs within a truncated appendage tactile stimuli simulating detected stimuli

These and other objects and advantages are achieved through an improved prosthetic device consisting of a frame including therein a socket for mounting the frame on a human appendage and a plurality of digits extended from the distal end of the frame, a plurality of transducers supported in the digits, for detecting tactile stimuli, and a slave unit configured to be strapped to the stump of a truncated appendage and connected with the sensing units so that tactile stimuli detected by the sensing units are communicated to sensory organs of the stump, through the slave unit

BRIEF DESCRIPTION OF THE DRAWING

FIG 1 is a pictorial view of a prosthetic device including therein a pressure transducer and a temperature transducer employed in detecting tactile stimuli

FIGS 2 and 3 are pictorial views depicting a slave unit electrically coupled with the device shown in FIG 1.

FIG 4 is a schematic view, in single-line, block diagram form, depicting circuitry employed in electrically interconnecting the transducers and the slave unit shown in FIGS 1 through 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIG 1 an improved prosthetic device 10 which embodies the principles of the instant invention.

As illustrated, the device 10 is an electro-mechanical hand of any suitable design Since prosthetic devices, such as electro-mechanical hands, are well known and form no specific part of the instant invention, a detailed description of the device 10 is omitted in the interest of brevity Suffice it to understand that the device 10 includes suitable mechanical drive units, not shown, including motors and the like for driving extended digits of the device in a cyclic operation Furthermore, it is to be understood that the device 10 may, if so desired, assume the configuration of a foot rather than a hand. Accordingly, it should be apparent that while the described embodiment of the instant invention is included within an artificial hand, the invention can be embodied in prosthetic devices of other appendages equally as well

The digits of the device 10, designated 12 and 14, support, near their distal ends, suitable sensing units which respond to applied tactile stimuli to provide electrical output signals of a magnitude proportionate to th magnitude of the stimuli. As illustrated, within the digit 12, which represents the thumb, there is seated a pressure transducer 16, while within the digit 14, which represents a finger, there is a temperature transducer 18. It is to be understood that the transducers 16 and 18 are of any suitable design capable of providing intelligence signals indicative of detected changes in prevailing conditions. Preferably, the transducer 16 is a piezo diode or tactile sensor which responds to an application of pressure to provide an electrical output signal indicative of applied stress. Such a device is referred to in the aforementioned patent to Fraioli. Similarly, the temperature transducer 18 responds to temperature changes for providing an electrical output signal at a voltage level dictated by the temperature of the transducer Preferably, the temperature transducer 18 is a variable resistance unit having thermally variable conductivity characteristics for providing electrical output signals, the magnitude of the amperage of which varies proportionally to changes in the temperature of the resistance

Hence, due to the innate characteristics of the transducers, the voltage levels of the intelligence signals derived from the transducers 16 and 18 increase and de-

crease proportionally with the magnitude of the applied stimuli For example, in the event the pressure transducer is subjected to increasing stress, the intelligence signal derived from the transducer 16 is of an increasing magnitude Similarly, the inteligence signal derived from the transducer 18 is increased proportionally with the increases in the temperatures to which the transducer is subjected

The transducers 16 and 18 are coupled electrically with a slave unit 20, which is activated in response to driver signals received from a power circuit 22 controlled by the intelligence signals provided by the transducers 16 and 18. The power circuit 22 is mounted at any suitable location, including the cuff portion of the device 10. It should be apparent that the circuit 22 can be deployed at any suitable location relative to the device 10 so long as the circuit is interposed electrically between the transducers 16 and 18 and the slave unit 20. Furthermore, it is to be understood that electrical connections are suitably effected through a use of electrical lead wires in accordance with currently acceptable circuit design and fabrication practices

As illustrated, the pressure transducer 16 is coupled with the power circuit 22 through electrical lead wires 24 extended from the thumb 12 while the transducer 18 is coupled with the power circuit 22 through suitable lead wires 26 extended from the forefinger 14. Similarly, the power circuit 22 is coupled with the slave unit 20 through a plurality of lead wires 28 which extend along the surface of the truncated appendage.

The slave unit 20 preferably includes a pair of electrically energizable solenoids 30 and a resistance heating element 32 suitably mounted on a strap 34. The strap 34 preferably is a flexible strap which, when employed, is buckled about the stump of a truncated appendage for bringing the solenoids 30 and the element 32 into contiguous engagement with the skin of the wearer In practice, the solenoids 30 include axially extensible armatures, not designated, mounted to act in substantial opposition so that when energized a "pinching" of the flesh of the stump is effected for thus stimulating the sensory organs located therein. Consequently, the magnitude of the thus applied pressure is recognized by the wearer

Similarly, the resistance heating element 32 is supported in contact with the skin of the stump so that as the temperature of the element 32 is elevated, the wearer of the device becomes cognizant of a change in temperature as the sensory organs in the stump respond to the changes in temperature occurring in the element 32.

The power circuit 22 preferably is fabricated employing solid-state devices and is mounted on a circuit board in a manner consistent with currently employed circuit design techniques The power circuit 22 preferably is energized through a portable D C (Direct Current) power source or battery pack 36, also supported at a convenient location within the device 10. The power source 36, of course, also is coupled with the transducers 16 and 18 in a manner such that an electrical potential is applied thereacross in order that there is established an electrical condition for the transducers This condition is subject to modification, in the presence of selected tactile stimuli, in a manner consistent with the function of piezo diodes and the temperature sensitive resistances, aforediscussed.

To the pressure transducer 16 there is coupled a voltage amplifier 38 coupled within the power circuit 22, while the temperature transducer 18 is coupled with a voltage amplifier 40. It is to be understood that the amplifiers 38 and 40 are employed to provide driver signals at a voltage level substantially above the voltage level of the intelligence signals derived from the transducers 16 and 18. Accordingly, the amplifiers 38 and 40 include solid state devices particularly suited for this function.

The output or driver signal derived from the amplifier 38 is fed to the solenoids 30 while the driver signal derived from the amplifier 40 is fed to the resistance heater 32 through the leads 28. The driver signal thus delivered from the amplifier 38 simultaneously is applied across the coils of the solenoid 30 for electrically energizing the solenoids to extend their armatures simultaneously to perform a pinching function Similarly, the signal derived from the amplifier 40 is applied across an electrical resistance heater element, not shown, for elevating the temperature of the resistance heater 32.

It should therefore be apparent that the slave unit 20, in effect, duplicates the tactile stimuli detected by the transducers 16 and 18 and applies the stimuli directly to the sensory organs within the stump of the appendage Due to the fact that the sensitivty of the sensory organs within the stump may vary, the output derived from the amplifier circuits 38 and 40 should be a variable voltage proportionate with the volatage level of the intelligence signals

OPERATION

It is believed that in view of the foregoing description, the operation of the device will be readily understood and it will be briefly reviewed at this point

With the slave unit 20 fixed to the stump of an appendage, the prosthetic device 10 is mounted on the stump, in a manner which forms no part of the instant invention Further, the device 10 is, when operated, manipulated in a manner consistent with the design and operation of prosthetic devices, so that the digits 12 and 14 are caused to engage selected surfaces, such as the surfaces of objects being grasped This grasping of objects causes tactile stimuli to be applied to the surfaces of the digits through taction As the hand closes, stress is applied to the pressure transducer 16 whereby an intelligence signal is delivered from the transducer to the amplifier 38, whereupon an amplified driversignal is provided and transmitted to the pair of solenoids 30 of the slave unit 20. Since the solenoids are located at substantially opposite sides of the stump, the armatures of the solenoids simultaneously are extended in opposition to "pinch" the stump therebetween and thus communicate pressure to the sensory organs within the appendage. Of course, increasing stress at the transducer 16 serves to increase the voltage level of the driver signal derived from the amplifier 38, for thereby increasing the pinching effect of the solenoids 30. Hence, the pinching effect of the solenoids is directly proportional to the applied stress at the pressure transducer 16. Once the stress is removed from the transducer 16, the solenoids 30 are de-energized and returned to their inactive position Thus, the stress applied at the transducer 16 is communicated to the sensory organs within the appendage for communicating the magnitude of the stress to the wearer of the device.

Where the transducer 18 located in the forefinger of the device 10 encounters an elevated temperature, an increase in the conductivity of the electrical current applied from the power source 36, through the transducer, is experienced As the current through the transducer 18 is increased, the amplifier 40 serves to provide a driver signal which is then applied to the resistance heater 32. As the voltage level of the driver signal, applied by the amplifier 40 to the resistance heater 32, is increased, the temperature of the heater element within the resistance heater is increased and transmitted to the sensory organs within the skin of the wearer of the device Thus an increased temperature at the transducer 18 is communicated to the sensory organs of the appendage through the resistance heater 32 so that the increased temperature is communicated to the wearer of the device

In view of the foregoing, it should readily be apparent that the improved prosthetic device of the instant invention provides a practical solution to the age-old problem of protecting a wearer by communicating ambient conditions to which a prosthetic device is subjected to the sensory organs of the wearer

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the illustrative details disclosed

I claim

1. Tactile Sensing Means for a prosthetic limb of the type including a terminal member having a plurality of digits extending therefrom through which taction is applied and means fo mounting the limb on a human appendage comprising

a temperature transducer and a pressure transducer supported by said digits for detecting tactile stimuli and providing electrical output signals proportionate to the magnitude of said stimuli,

a pair of opposed solenoids electrically coupled with said pressure transducer,

a resistance heater electrically coupled with said temperature transducer,

strap means for mounting said solenoids and said heater on said appendage in contiguous engagement therewith with the armatures of said solenoids disposed on opposite sides of said appendage whereby as taction is applied to said digits, tactile stimuli are detected by said sensing means and communicated to said appendage proportionate to the magnitude of said stimuli, with said armatures when energized applying pressure to the flesh of said appendage and said heater applying heat to said appendage

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